REMARKS

This amendment is responsive to the Office Action mailed February 7, 2008. Reconsideration and allowance of the claims 2-6, 8, 10, 12-14, 16, 17, 20, 21, and 23-28 (all claims) are requested.

The Office Action

The Feb. 7th Office Action reports examination of claims 1-27.

Claims 1, 2, 6-12, and 18 stand rejected under 35 U.S.C. § 102(b) as allegedly anticipated by Harvey, U.S. Pat. No. 6,275,038 (hereinafter "Harvey").

Claims 1, 3-5, 14, 15, 19, 26, and 27 stand rejected under 35 U.S.C. § 102(a) as allegedly anticipated by Roopchansingh et al., U.S. Publ. Appl. No. 2004/0254449 (hereinafter " Roopchansingh").

Claims 20-25 stand rejected under 35 U.S.C. § 103(a) as allegedly unpatentable over Roopchansingh in view of Ehnholm et al., U.S. Pat. No. 5,882,304 (hereinafter "Ehnholm").

Claims 13, 16, and 17 are indicated as containing allowable subject matter.

The claims present patentable subject matter and should be allowed

Claim 6 has been amended to incorporate subject matter of canceled claims 1 and 7, and has further been amended to recite applying a spatially nonselective radio frequency excitation, support for this recitation being found in the original specification at least at page 8 lines 15-22.

Claim 6 recites performing magnetic resonance imaging in a main magnetic field; and measuring spatial data corresponding to the main magnetic field by applying a spatially nonselective radio frequency excitation, reading at least two gradient echoes using magnetic field gradients imposed along a selected direction, computing a nonuniformity of the main magnetic field along the selected direction from the at least two gradient echoes, repeating the reading and computing for a plurality of selected directions, and mapping the main magnetic field based on the

computed nonuniformities along the selected directions; wherein the measuring of spatial data corresponding to the main magnetic field is performed concurrently with the performing of magnetic resonance imaging.

Harvey discloses real time magnetic field mapping using a modified echo planar imaging (EPI) pulse sequence. Harvey col. 5 lines 56-58. Such a sequence employs a spatially selective radio frequency excitation, followed by acquiring k-space data across the selected slice. Harvey Fig. 1 illustrates such a modified EPI sequence, in which a radio frequency pulse (22) applied in conjunction with a slice-selective magnetic field gradient (24) provides the spatially selective radio frequency excitation. Slice-selective refocusing is provided by a second spatially selective radio frequency pulse (26) applied in conjunction with a spatially selective magnetic field gradient (28). An EPI readout sequence follows therafter, comprising oscillating magnetic field gradients (36, 40, 42) producing data signal (46). Other sequence embodiments shown in Harvey Figs. 3 and 5 also include these features.

The modified EPI readout sequence of Harvey has at least two disadvantages – it includes temporally extended readout waveforms (36, 40, 42), and it provides mapping for only the selected slice.

Compare this with the illustrative embodiment of the present application shown in present application Fig. 4. A spatially nonselective radio frequency excitation is formed of the rf pulse (122) alone, without any simultaneously applied spatially selective magnetic field gradient. As a result, a volume is excited, rather than just a slice. This is followed by gradient echoes (126) and (140, 142) using magnetic field gradients imposed along selected directions. The gradient echoes are geometrically different from the EPI readout waveforms of Harvey – while Harvey acquires k-space samples across the selected slice, the gradient echoes (126) and (140, 142) of the present application illustrative example are reconstructed into projections. Present application at page 8 lines 29-31. In the illustrative example, the first gradient echo (126) is along the conventional slice-select direction (this being a spatial direction designation and not denoting the use of any slice-selective gradients during excitation). The second gradient echo (140, 142) is along a direction intermediate between the phase-select and readout directions, due to the simultaneous application of the phase-select gradient (140) and the readout gradient (142).

EPI-based magnetic field mapping of a slice as disclosed by Harvey is fundamentally different from projection-based volumetric magnetic field mapping as disclosed in the present application. This difference is brought out in claim 6 at least by the recitation of applying a spatially nonselective radio frequency excitation, repeating the reading and computing for a plurality of selected directions, and mapping the main magnetic field based on the computed nonuniformities along the selected directions.

These deficiencies of Harvey cannot be remedied by the Roopchansingh or Ehnholm references. Roopchansingh also employs an EPI-based slice mapping technique. See the pulse sequence of Roopchansingh Fig. 2 which includes a spatially selective excitation (34, 36) with a slice-selective magnetic field gradient (36), and a temporally extended oscillating EPI-type readout waveform (44, 46). Ehnholm is unrelated to main magnetic field mapping.

Dependent **claim 8** further recites applying a balanced magnetic field gradient along the selected direction, the balanced magnetic field gradient having at least two lobes of same polarity separated by a lobe of opposite polarity. In contrast, Harvey applies an oscillating EPI-style readout waveform that acquires k-space samples across the selected spatial slice.

Dependent **claim 10** further recites applying a spatially nonselective radio frequency excitation having a low flip angle of less than about 5 degrees. The amendment of this claim is supported in the original specification at least at page 8 lines 16-19. While Harvey discloses using a shallow flip angle (col. 4 lines 62-63), Harvey does not specify a low flip angle of less than about 5 degrees.

Dependent **claim 12** recites Fourier transforming each gradient echo to reconstruct a projection along the selected direction, and computing a complex phase difference between the projections reconstructed from the at least two gradient echoes, the nonuniformity of the main magnetic field along the selected direction corresponding to the complex phase difference. This claim stands rejected based on citation to Harvey col. 3 lines 55-67. It is respectfully submitted that this passage of Harvey discloses reconstruction of the k-space data to produce a slice image, as is conventional in Fourier transform-based image reconstruction techniques. The Fourier transform of Harvey does not reconstruct a projection along the selected direction.

Dependent **claim 13** was indicated as containing allowable subject matter. It is respectfully submitted that the amendment of base claim 6 does not alter the conclusion that claim 13 contains allowable subject matter.

Accordingly, it is respectfully submitted that claims 2-6, 8, 10, and 12-14 presents patentable subject matter, and Applicants respectfully request allowance of claims 2-6, 8, 10, and 12-14.

Claim 16, which is indicated as containing allowable subject matter, has been placed into independent form including all limitations of base claim 1. Accordingly, Applicants respectfully request allowance of claims 16 and 17.

Claim 20 recites a magnetic resonance imaging scanner configured to perform magnetic resonance imaging in a main magnetic field and a plurality of magnetic field sensors disposed at different positions in the main magnetic field. The plurality of magnetic field sensors operate independently from the magnetic resonance imaging scanner, and the plurality of magnetic field sensors are configured to measure spatial data corresponding to the main magnetic field. A processor is configured to determine at least one main magnetic field nonuniformity parameter from the spatial data corresponding to the main magnetic field. The amendment calling for the sensors to be disposed at different positions in the main magnetic field finds support in the original specification at least at page 6 lines 10-20.

Claim 20 stands rejected based on a proposed combination of Roopchansingh and Ehnholm. The Office Action acknowledges that Roopchansingh does not disclose magnetic field sensors as recited in claim 20 (Office Action at page 6) and proposes to remedy this deficiency of Roopchansingh by Ehnholm's disclosure of Hall effect sensors at col. 7 lines 25-27.

Ehnholm discloses a Hall effect sensor in the context of measuring orientation of a biopsy needle:

> The described procedure can be facilitated further if, in addition to its position, the orientation of the biopsy needle 38 can be determined. This can be accomplished by adding a magnetic

> field sensor or sensors such as a coil, a Hall effect sensor or second ESR-magnetometer at a defined location on the probe 1.
>
> Ehnholm col. 7 lines 25-27.

In the orientation application of Ehnholm, a magnetic field sensor is attached to the biopsy needle, and is used to determine the orientation of the biopsy needle respective to the main magnetic field. Ehnholm does not employ a Hall effect sensor to measure nonuniformity of the main magnetic field – rather, Ehnholm uses the main magnetic field as a spatial reference for determining the biopsy needle orientation.

It is respectfully submitted that Ehnholm falls far short of disclosing or fairly suggesting the plurality of magnetic field sensors recited in claim 20. A single magnetic field sensor as disclosed in Ehnholm is not sufficient to measure spatial data corresponding to the main magnetic field from which at least one main magnetic field nonuniformity parameter can be determined. Ehnholm uses its magnetic field sensor to determine orientation of the sensor (and hence orientation of the attached biopsy needle) in the static magnetic field. This application entails determining only the local magnetic field in the immediate vicinity of the Hall effect sensor.

Ehnholm does not disclose or fairly suggest a <u>plurality</u> of magnetic field sensors operating independently from the magnetic resonance imaging scanner and <u>disposed at different positions in the main magnetic field</u> and configured to measure spatial data corresponding to the main magnetic field <u>from which a processor can determine at least one main magnetic field nonuniformity parameter</u>.

Still further, Roopchansingh itself teaches away from the subject matter of claim 20, by affirmatively disclosing means for measuring main magnetic field nonuniformity that integrally incorporates the magnetic resonance imaging scanner. Indeed, Roopchansingh uses the magnetic resonance imaging scanner to acquire the spatial data from which is determined the main magnetic field nonuniformity.

A reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention. MPEP § 2141.02. It is improper to combine references where the references teach away from their combination. MPEP § 2145. The proposed combination of Roopchansingh and Ehnholm fails to disclose or fairly suggest a plurality of magnetic field sensors as

recited in claim 20, and Roopchansingh actually teaches away from subject matter recited in claim 20.

Accordingly, it is respectfully submitted that claim 20 presents patentable subject matter, and Applicants respectfully request allowance of claims 20, 21, 23-25 and 28.

CONCLUSION

For the reasons set forth above, it is submitted that all claims distinguish patentably over the references of record and meet all statutory requirements. An early allowance of claims 2-6, 8, 10, 12-14, 16, 17, 20, 21, and 23-28 (all claims) is requested.

In the event the Examiner considers personal contact advantageous to the disposition of this case, she is requested to telephone Thomas Kocovsky at (216) 861-5582.

Respectfully submitted,

FAY SHARPE LLP

Thomas E. Kocovsky, Jr.
Reg. No. 28,383
Robert M. Sieg
Reg. No. 54,446
1100 Superior Avenue, 7th Floor
Cleveland, OH 44114-2579
(216) 861-5582